

*X. An Account of Rings consisting of all the Prismatic Colours, made by Electrical Explosions on the Surface of Pieces of Metal, by Joseph Priestley, LL. D. F. R. S.*

Read March 10, 1768.

**I**T was a discovery of Sir Isaac Newton, that the colours of bodies depend upon the thickness of the fine plates which compose their surfaces. He has shown that a change of the thickness occasions a change in the colour; differently coloured rays being thereby disposed to be transmitted through the plate, and consequently rays of different colours being disposed to be reflected at the same place, so as to present the appearance of different colours to the eye.

A variation in the density of the plate, he shows, will occasion a variation in the colour; but still a medium of any density would exhibit all the colours according to the thickness of the different parts of it. These observations he confirmed by experiments on plates of air, water, and glass. He also mentions the colours which arise on polished steel, by heating it; as likewise on bell-metal, and some other metalline substances, when melted and poured on the ground, where they may cool in the open air: and he ascribes these colours to the *scoriae*, or vitrified parts of the metal, which, he says, most metals, when heated, or melted, do continually protrude, and send out to their surface, covering them in the form of a thin glassy skin. *Optics*, pag. 194.

This capital discovery, concerning the colours of bodies depending upon the thickness of the fine plates

plates which compose their surfaces, of whatever density those plates be (and which may be of such admirable use to explain the colours, and perhaps, in due time, the constituent parts and internal structure of natural bodies) I have been so happy as to hit upon a method of illustrating and confirming, by means of electrical explosions. These, being received upon the surfaces of all the metals, change the colour of them, to a considerable distance round the spot on which they are discharged, so that the whole space is divided into a number of concentric circular spaces, each exhibiting all the prismatic colours; and perhaps as vivid as they can be made in any method whatever.

It was not by any reasoning *a priori*, but by a mere accident, that I first discovered these colours. Having occasion to take a great number of explosions, in order to ascertain the lateral force of them; I observed that a plate of brass, on which they were received, was not only melted, and marked with a circle, by a fusion round the central spot, but likewise tinged, beyond this circular spot, with a green colour, which I could not easily wipe out with my finger. Struck with this new appearance, I replaced the apparatus, and continued the explosions; till, by degrees, I perceived a circle of red beyond the fainter colours; and, examining the whole with a microscope, I plainly distinguished all the prismatic colours, in the order of the rainbow. The diameter of the red, in this instance, happened to be one third of an inch, and the diameter of the purple about one fourth.

Pleased with this experiment, I afterwards pursued and diversified it in a great variety of ways, the result of which I shall comprise in the following observations.

i. When

1. When a pointed piece of metal is fixed opposite to a plain surface, the nearer it is placed to the surface, the sooner do the colours appear, the closer do the rings succeed one another, and the less space they occupy; as, on the other hand, the farther it is placed from the surface, the later do the colours appear; but the rings then occupy a proportionably greater space, and have more room to expand themselves. N° 1. on the steel \*, was made by the explosions passing from the point of a needle, fixed at the distance of  $\frac{2}{5}$  of an inch from the steel; and N° 2. was made at the same time, when the needle was placed at the distance of  $\frac{1}{2}$  of an inch. It seems, however, that when the point is placed at such a distance, as that the electric matter has room to dilate, and form as large a circular spot as the battery will admit, the rings are as large as they are capable of being made; but that still the colours appear later, in proportion to the distance beyond that. When the point is fixed exceeding near, or is made to touch the surface, the colours appear at the very first explosion, but they spread irregularly, and make not distinct rings, as N° 1. upon the tin.

2. The more acutely pointed is the wire, or needle, from which the electric matter issues, or at which it enters, the greater number of rings appear. A blunt point makes the rings larger, but fewer; and in that circumstance it is likewise much later before the colours make their appearance at a given distance. N° 3.

\* All the coloured rings mentioned in this paper were shewn to the Royal Society, but could not be well represented by a print.

upon the steel, was made by a blunt wire, and N° 2. upon the tin by a brass knob fixed opposite to it.

3. In making these rings, the first appearance is a dusky red, about the edges of the circular spot; presently after which (generally after four or five strokes) there appears a *circular space*, visible only in a position oblique to the light, and looking like a shade on the metal. This space expands very little during the whole course of the explosions, and it seems to be, as it were, an attempt at the first and faintest red; for by degrees, as the other colours fill the bulk of that space, the edges of this shade deepen into a kind of brown; as may be seen particularly in N° 4. upon the steel, where it is something more than half an inch in diameter, and in N° 1. where it is near  $\frac{3}{4}$  of an inch.

4. After a few more explosions, a second circular space is marked out by another shade, beyond the first, generally about  $\frac{1}{6}$  or  $\frac{1}{5}$  of an inch in diameter, which I have never observed to change its appearance, after ever so many explosions. This second shade, by succeeding the first; which as I observed, becomes gradually of a brown, or a light red, seems to be an attempt at the fainter colours, which intervene between the reds.

5. All the stronger colours make their first appearance at the edges of the circular spot; and more explosions make them continually expand towards the extremity of the space first marked out, while others succeed in their place; till, after about thirty or forty explosions, three distinct rings generally appear, as in N° 4. upon the steel. If the explosions be continued farther, the circle becomes less beautiful, and less distinct;

tinct; the red commonly prevailing, and suffusing all the other colours, as in N° 1. upon the steel; though I attribute the confusion of the colours in that circle, in part, to the needle having been several times accidentally broken from the cement which supported it, and to its not having been replaced exactly as before.

6. The last formed colours are always the most vivid, as appears very distinctly in the reds of N° 1 upon the steel. Also the last formed rings lie closer to one another than the first.

7. These rings may be brushed with a feather, and even wetted, or a finger may be drawn over them, without their receiving any injury; but they easily peel off, when scratched with one's nail, or any thing that is sharp, the innermost rings being the most difficult to erase.

8. The first circles are sometimes covered with a quantity of black dust; part of which however may be wiped off with a feather, so as to show the colours under it. An attempt to wipe off more, on the rough side of the steel, took off the colours along with it; but more than half yet remains, with the dust upon it, as it was first formed.

9. It makes no difference whether the electric matter issue from the pointed body upon the plate, or from the plate upon the pointed body; the plate opposed to the point being marked exactly alike in both cases. Also the points themselves, from which the fire issues, or at which it enters, are coloured to a considerable distance, often about half an inch, but not very distinctly. The colours likewise return here, in concentric rings, as upon the plate.

10. I think

10. I think that the more circles are made at the same time, the more delicate will the colours be; whereas the surface is, as it were, torn, or corroded by more violent explosions; which makes the colours appear rough and coarse. N° 4. is I think on this account, as well as some others, marked in a more delicate and beautiful manner than N° 1. or N° 5. But this roughness is only perceived on the steel. On silver, tin, and polished brass, the colours were always free from that roughness.

11. A polished surface is not necessary, the colours being very manifest on the rough side of the steel, where it is not covered with the black dust mentioned above.

12. These coloured rings appear almost equally well on all the metals on which I have made them; namely, gold, silver, copper, brass, iron, lead, and tin.

I have not tried any of the semi-metals; but I have no doubt of their answering as well as the proper metals.

13. When the pointed wire was made to incline to the plane on which the colours were exhibited, the circular spot was quite round, the center of it being in the perpendicular let fall from the point; but the colours were projected opposite to the point, in an oblong figure.

Upon shewing these coloured rings to Mr. Canton, I was agreeably surprised to find, that he had, likewise, produced all the prismatic colours from all the metals, but by a different electrical process. His method had been to extend fine wires over the surface of pieces of glass; and when the wire was exploded, he observed that the glass remained tinged

with all the colours from all the metals. They are not indeed disposed in so regular and beautiful a manner as in the rings I produced; but they equally demonstrate, that none of the metals discovers the least preference to any one colour more than another. A variety of other very extraordinary appearances occurred in the course of Mr. Canton's experiments in melting wires.

In what manner these colours are formed, it may not be easy to conjecture. In Mr. Canton's method of producing them, the metal seems to be dispersed in all directions from the place of explosion, in the form of spheres, of a very great variety of sizes, tinged with all the variety of colours, some of them too small to be distinctly visible by any magnifier. In my method, it should rather seem that they are produced in a manner similar to the production of colours on steel &c. by heat *i. e.* the surface is affected, without the parts of it being removed from their places, certain plates only, or *laminae*, being formed, of a thickness proper to exhibit the respective colours at certain distances; and that the thickness of these plates is continually changing by the repetition of the explosions.

N. B. The *battery* made use of in the abovementioned experiments was of *twenty one square feet* of coated glass.